A Powerful Macro-model for the Computer Patient Record

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ABSTRACT

Especially in the Netherlands, the introduction of computer patient records (CPRs) in primary care has been relatively successful. Specialists usually maintain more extensive records than general practitioners and it has proven to be a great challenge to design a CPR that is useful and practical for specialized care. In this paper, we present the design of a CPR for use by specialists in an out-patient clinic. The philosophy underlying the design is that specialists may keep record in a relatively conventional way, while, at the same time, the system motivates them to add structure to their data. Data can be presented in various views, each suitable for one or more specific tasks. The potential to benefit from these views depends on the degree of structure in the recorded data. Since a CPR has to be faithful and permanent, explicit representation of observations, insights, and evolution of insight is also supported. The CPR system is in a final stage of implementation and will be evaluated in a clinical setting in summer 1994.

INTRODUCTION

Although the paper medical record (PMR) is still the most widely used medium for storage of patient data, advances in computer technology and an increase in complexity of health care have made the shortcomings of PMRs more apparent [1-4]. Depending on the viewpoint, different shortcomings are recognized. From a pragmatic point of view, the PMR can only be consulted in one place at a time, the legibility of hand-written sections may be poor, and information may be missing or difficult to find if the document is not well organized. Paper records often contain redundant information as a partial compensation for the fact that multiple views on the contents cannot be created dynamically. Where forms provide structure in the presentation of data, they introduce inefficiency at the same time, because they lead to sparse data storage: a form has to accommodate a large variety of possibilities while only few of those will apply to a certain patient. From the viewpoint of research, retrieval from PMRs involves a labor intensive search. Additionally, interpretation of the contents may be hindered by lack of standard terminology and completeness of data. While collecting data for analysis, transcription errors may occur. Furthermore, the PMR is passive: it cannot check the validity or plausibility of data and it cannot produce warnings for abnormal data or prompt for information in the context of a research protocol.

Electronic storage of patient data already provides a solution for part of these shortcomings: data can be accessed from several locations at the same time and legibility is no longer an issue. However, reduction of the other shortcomings requires more than storing free text. When information is identifiable in the record data can be presented in several views, thereby eliminating the need for redundancy. These potential advantages have lead to a great interest in CPRs, and the Medical Records Institute has encouraged their use. However, the benefit of such records highly depends on the amount, type, and reliability of the information they hold.

Although it is recognized that the degree of structure in a CPR determines much of its potential benefits [2,5], there is a tension between these benefits and the effort of structured data entry [6]. Physicians may prefer a few selections of predefined items over typing free text, but as soon as structured data entry involves a battery of menus and forms, they will refrain from data entry by computer. As a result, the most widely used CPR systems have clerical personal enter data that physicians record on system print-outs [2,7-9]. The physicians may use the system for consultation of information but they still make notes on structured forms. It is obvious that data entry by others than the physician himself is prone to transcription errors [10].

In the Netherlands, about 26% of the general practitioners (GPs) have completely replaced their PMRs by CPRs [11]. The efforts by professional organizations and support by the government have played an important role in this success. Yet, the records kept by GPs are far less extensive than those usually maintained by specialists. Therefore, because of the quantity of information involved, the step to computerized recording is more difficult to take for specialists. In our research, we focused on the development of a CPR for the out-patient clinic of a

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medical specialist, the internist in particular. In the following sections, we will present the philosophy behind our work, our CPR model, and discuss how the philosophy comes to expression in that model.

PHILOSOPHY

Even when physicians cannot directly be motivated to enter data by computer, there is still the challenge to expose the physician to the (potential) benefits of a structured CPR. Nygren has conducted important research on the use of PMRs by physicians [12]. He found that the clinical question greatly influences how the PMR is searched for relevant data. The ordering and structure of documents is vital to the efficiency of this search. Where Nygren provided insight in the type of information that physicians need in several clinical situations, Rector formulated foundations for CPRs [13]. These foundations constitute important criteria that CPRs should meet, with emphasis on the faithfulness and permanence of these records. The studies mentioned, have been the basis for the philosophy of our model. The following requirements have been the starting point of our research:

1) In order to be faithful and permanent, the record should allow for recording of observations, insight, and evolution of insight.

2) Allow for record keeping that offers options for structuring, but lets the physician free to choose for free text, at least for history and physical exam.

3) Offer views on patient data, each suitable for one or more specific tasks. The interface should motivate the physician for more structured data entry by making apparent how he can benefit from it.

4) Support structured data entry by intelligent and flexible anticipation of what the physician may want to describe.

THE MODEL

In our CPR, we distinguish 1) the macro-structure and 2) the micro-structure. The macro-structure comprises the components of the medical record, such as history, physical exam, lab data, diagnoses, problems, and the relationships between these. The micro-structure involves a detailed formal representation of the findings that otherwise constitute the free text portions history and physical exam [14,15]. Within this paper, we restrict ourselves to the model of the macro-structure.

Record keeping involves recording of information over time. Fig. 1 shows the three basic components of the macrostructure and how these are related to time and to each other.
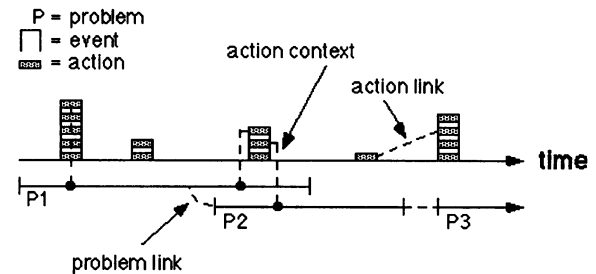

Fig 1 The three basic components of the CPR model with their relations to time and to each other.

Actions are the smallest units of information in the macro-model. Examples are a history, a physical exam, a lab result, and a prescription. Some of these actions, such as history and physical exam, have no further structure in the macro-model and are represented by one text field. Others consist of a number of specific fields: testname, value, and units in case of a lab result, and drug name, dose, frequency, and total amount in a case of a prescription. The *event* embodies a set of one or more actions that belong together in the sense that they can be considered to have been entered at one moment, have been discovered at one moment, are valid from one moment, and originate from the same source. The most typical example is the patient visit, but one lab report with several test results is also an event. Which actions may be described within a certain event type is defined in the model. The event-action model leaves room for several degrees of structure: a physician may choose to use only the action "summary" for all his text, whereas another physician may decide to partition his information over different actions, such that history, physical exam, diagnosis, etc., can be distinguished. The events and their actions represent what the physician has observed or done (decided).

The third component in the macro-structure is the *problem*, which was introduced by Weed [16]. Problems constitute conditions for which the patient is being evaluated and/or under treatment.

Besides structuring direct observations and decisions, the physician can add structure on a higher level by defining links between the basic components of the model. The first type of link, between an action and a problem, is called the action context and provides for

the possibility of problem-oriented record keeping: observations, test orders, and treatments can be put in the context of a problem. There are several predefined descriptions to express the meaning of the link. Examples are: the physical exam *is related to* problem A, or problem A *is indication for* lab request B. The second type of link is between actions. This link type provides for refined expression of indications such as: test result A *is indication for* prescription B. Finally, by means of the third link type, problems can be linked to each other to express whether one problem is *a recurrence of* an earlier problem, or *a complication of* another problem, etc. For all three link types, the physician has the option to also express the meaning of the link in his own words. Action context, action-action links, and problem-problem links reflect the physician's insights.

The requirement that the patient record is permanent, i.e. not editable afterwards, calls for the need to record evolution of insight. The physician must be able to record that he realizes **now** that some condition has been present **since** some moment in the past. A series of such entries would document evolution of insight. This will be illustrated with a diagnosis. A diagnosis is an action in the sense that it reflects the physician's decision about the medical label for the patient's condition. When a diagnosis is entered, it is mandatory to define its status: certain, under consideration, certainly not, or cured. Since the insight with respect to the status of a diagnosis can change, recording the status of a diagnosis is also an action. When recording the status of a diagnosis, three dates are recorded: 1) the moment of data entry, 2) the date since the physician has his current insight about the status, and 3) the date since when the status should be regarded applicable. With these three dates a physician can record **now** that he knows **since a week**, that the patient has condition A since **2 years**. An example is illustrated in Fig. 2.

E = moment of data entry   A = moment statement applicable
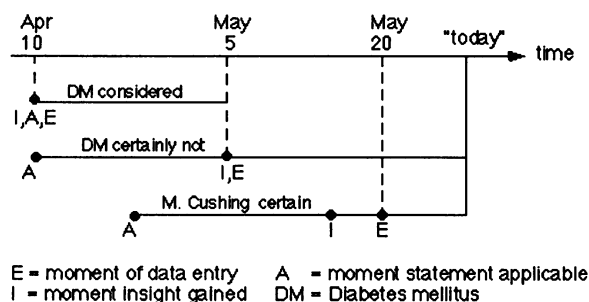I = moment insight gained   DM = Diabetes mellitus

Fig 2. A schematic representation of recording insight and evolution of insight regarding the status of a diagnosis.

The example in Fig 2 shows that Diabetes Mellitus (DM) was entered on April 10 as being *under consideration* since April 10. On May 5th, the physician realized that the patient did not have DM and changed the status of that diagnosis to *certainly not* since April 10. A few days before May 20, the results of a test in late April leads to the conclusion that the patient suffers from Cushing's disease. On May 20, the physician enters that he knows since a few days, that the patient had Cushing's disease for *certain* since at least the date of the test.

When re-evaluating test orders and treatment in the past, it is important to realize that insights **then** may differ from insights **now**. Although it is presently known that the patient suffers from Cushings' disease, all actions on May 2nd were still based on the suspiscion of diabetes.

Assessing the insights on a date in the past has its equivalent in a PMR in looking through the pages on or prior to that date. For the current insights one would start this search from the present backwards. The explicit representation of evolving insight is important for medical audit and decision support that involves temporal reasoning [17].

Besides the temporal aspects of recording, each observation and insight is always recorded with its author and its authorizer. The authorizer is the person, who is responsible for data entry into the CPR. The author represents the source of the information. In most cases, the authorizer is also the author, but it may happen that a neurologist conveys his insights to the treating physician. When the treating physician enters these insights into the CPR, he may record the neurologist as the author while he himself is the authorizer. Knowledge about the author, will facilitate consultation of the original information when the data is too concise or suspect for potential errors in transcription or interpretation.

PRESENTATION OF PATIENT DATA

As Nygren made explicit, it is important to present data in various views, each suitable for performing one or more specific tasks. Since the CPR can never "know" in advance which clinical question the physician wants to answer, the default view on the data should be based on anticipation of what the physician most likely wants to see. From there, the physician should be able to call for other views in an efficient manner, depending on his needs. In an out-patient clinic, the most frequent reason for consultation of a patient record is to obtain or recall the clinical picture of the patient. Our default view is based on that goal and is called the "patient profile" (PPF). Since the profile constitutes a view, it does not

simply compare to a page in the PMR. The profile represents which information on the patient is currently valid and involves a set of data from different parts of the CPR. The data presented are: problems, past history and sensitivities, medication and test results since last visit, dates of all previous visits, and those diagnoses, that are currently certain or under consideration. In a PMR, gathering this set of data may involve browsing through many pages. Drugs may have been prescribed on several dates in the past: the physician has to judge whether or not one or more of these have to be prolonged. Sensitivities may be visible on the cover of a paper chart, but they can also be hidden somewhere in the volume. Test results require browsing through several lab or X-ray sheets to see what the latest results are. In the PPF, all this information is retrieved by the system and presented to the physician in one view. Although the default date of the PPF is today, the physician can enter any date since the CPR was started, and the PPF will present the information and insight that was applicable on the specified date.

Fig 3. This patient profile window is derived from its Dutch equivalent. The PPF gives an overview of the patient data as they were valid on the specified date in the upper right part of the screen.

Besides serving as a view on the data, the PPF is also designed to provide immediate access to other information in the record, either by the option to call for another view or by zooming in on the data presented. The chronological overview presents a chronologically ordered list of all events that are stored in the CPR. Within this list, the physician has the option to limit his scope to events of a certain type such as "visit", or "blood test results". He can further

refine his scope to a certain problem. Hence it is possible to ask for all visits linked to the problem "renal dysfunction". Whether or not a view has been defined, selection of one of the events in the list gives direct access to the "page" involved. From there, the physician can step back or forward in time, within his scope.

The zoom-option corresponds to looking up a certain page in a PMR, such as the notes of a visit and the contents of test results.

DISCUSSION

The CPR model fulfils the objective of being faithful and permanent by its explicit representation of observations and insights in relation to time and source. The model also supports temporal queries for research or decision support. Drawing from the experience with Dutch GPs and other systems in ambulatory care [2,7-9], it seems that structured data entry via a controlled vocabulary is a relatively large step for medical specialists, especially for data conventionally recorded in free text [18-21]. Therefore, we have chosen to give the physician the option to keep a CPR that is fairly conventional in its degree of free text and structure. We believe that physicians will ultimately be motivated to add more structure to their records when the possible views on the data enhance their awareness of the potential benefits. When the patient profile only shows the dates of recent visits and nothing else, the physician may regret that he simply wrote all his information and decisions as free text in the summary fields of the patient visit screen. Even when he decides to record diagnoses as separate actions, it may happen that the PPF shows a cystitis as a diagnosis, that has been certain since a year. Such an experience may motivate the physician to also record when a diagnosis is no longer valid. Similar motivations can be given for separate recording of problems, prescriptions, and other actions. Likewise, the option to specify scopes in the chronological overview may stimulate the user to specify links between actions and problems. Finally, intelligent and flexible support of structured data entry on micro-structure level is the subject of a parallel research project that is beyond the scope of this paper [14,15]. However, the CPR model does already have the slots for this encoded descriptive information.

PRESENT STATUS

The macro-structure model of the CPR will be evaluated in a clinical setting in summer 1994,

tailored to the domain of cardiac failure. The CPR will be running as a service on the Hermes workstation, which supports access to and analysis of a variety of data from different databases [22].

CONCLUSION

Although we have ample experience with CPRs in primary care, developing a CPR, suitable for specialists, remains a great challenge. It is our philosophy that a CPR for specialists should allow its user to start record keeping in a way he can relate to, and from there encourage him to evolve into a record keeper that can enjoy the benefits of a structured CPR. Evaluation of our CPR in a clinical setting will reveal to which extent our philosophy applies and provide us with further insight in the use of patient data by specialists.

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